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Sustainable Geopolymer Bricks Incorporating Red Mud and Fly Ash: An Experimental Study

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Abstract **- In the present research the properties of water absorption (WA) and compressive strength of Geo-polymer bricks with Red mud and fly ash as ingredients in different proportions is studied. The results suggest that maximum CS of 12 N/mm2 is achieved with 70% fly ash and 30% Red mud and found to decrease with in percentage of Red mud. Water absorption showed decreasing trend with decrease in percentage of Red mud. Water absorption of 9.78 % is recorded for 80 % fly ash and 20 % Red mud and the result satisfies the requirement of less than 10 % as given in IS 3495-1992. Although, the strength gained is not significant and with acceptable water absorption percentage, Geopolymer bricks with Red mud and fly ash could be used as a sustainable construction material in rural areas**

Keywords: Geopolymer bricks, Red mud, Compressive Strength, Fly ash, Water absorption

I. INTRODUCTION

As a result of the overpopulation, there is a demand for basic necessities, which leads to construction activity and the production of industrial waste. The use of materials for a housing facility is part of the construction process[1]. To meet the demand of Construction materials there is need to find alternative building materials. Hence in this study an attempt is made to try the various industrial wastes materials to produce masonry bricks mainly redmud, flyash. That reduces the use of high energy material usage and also can effectively handle the global waste disposal issues being an efficient method to use waste by-products and to be an eco-friendly idea.

Burnt clay bricks are used extensively as construction material. The use of industrial waste products can be the alternative for construction. The unrestricted use of clay is hazardous to society because all of India's brick kilns rely on good grade clay [3]. Making bricks is both environmentally and economically beneficial, as it saves valuable top agricultural soil while also meeting the social goal of disposing of industrial waste. The ever-increasing amount of fly ash produced around the world has not been nearly matched by its use. However, it is unjustifiable for the brick business to adopt a similarly cautious stance [6].

In some places of the world, where coal is the primary source of energy and bricks are the primary building material, environmental concerns have been raised. As a result of these concerns, legislation has been enacted requiring the brick industry to integrate at least 25% by weight of fly ash and/or bottom or pond ash in the brick producing mixture if the industry is located within 50 kilometres of a coal power station. Fly ash is the by-product of powdered coal burning. There have been some successful initiatives where fly ash was included into the mixture [9]. Even when the law was followed, there is scant indication that the amount of fly ash in the brick mixture exceeded 30 percent by volume.

II. OBJECTIVES & METHODOLOGY

The main objectives of this study is listed below.

• To explore possibility of using red mud with significant of mineral admixture FLYASH as ingredient in geo-polymer composites.
• To check compatibility of combination of red mud and FLYASH in the production of geo-polymer masonry bricks.
• To produce geo-polymer masonry bricks with different combinations of red mud and FLYASH with addition of chemical activator.
• To find optimum percentage of combinations of ingredients to obtain quality geo-polymer masonry bricks on the bases of their mechanical property such of compressive strength with water absorption.

The following steps were followed to accomplish the work

1. Procuring raw materials for the studies such as redmud, Flyash, NaOH, Na_2SiO_3 and water.
2. Determining characteristics of procured materials.
3. Determining the mix proportions for all combinations.
4. Producing geo-polymer block using different proportion using NaOH and Na_2SiO_3 as alkaline activators.
5. Determination of strength properties after curing.

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III. MATERIALS CHARACTERIZATION

There are different types of materials are used in preparation of geo-polymer brick are as follows.

1. Red Mud.
2. Fly Ash
3. Chemical Activators.

a. Sodium Hydroxide

b. Sodium Silicate.

4. Water

REDMUD

It is collected from Hindalco Industries Pvt Limited, Belagavi: fine red mud which is passing through 425 micron. The bauxite residue by-product of the Bayer process.



Fig. 1. Redmud

Table 1. Geotechnical properties of Red mud

Sl No	Particular of Test	Values
1	Specific Gravity	2.80
2	OMC	15.10 %
3	Maximum Dry Density	2.50 g/cm^3

FLYASH: It is procure from Raichur Thermal power plant, Karnataka, India. The material property is as follows

Table 2**.** Geotechnical properties of FA

Sl No	Particular of Test	Values
1	Specific Gravity	2.2
2	Colour	Light Grey
3	Liquid Limit	31.10 %
4	Density	1.50 g/cm^3

ALKALINE SOLUTION

• The sodium hydroxide (1) to sodium silicate (2.5) ration is used.

• Sodium hydroxide solution with a concentration of 8 molar is used to study the workability of mix and to produce the bricks.



Fig. 2. NaOH Flakes



Fig. 3. Sodium silicate solution



Fig. 4. Redmud & Flyash dry mix

IV. PRODUCTION OF BRICKS

PREPERATION OF SOLUTION

Distilled water and Sodium Hydroxide is mixed first one day prior. Then sodium silicate solution was added before adding it to constituents produce mix.



Fig. 5. Prepared Alkaline Solution

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MIXING: The solid constituents are mixed dry for 3 to 5 minutes. The alkaline solution was then added, and the mixture was stirred for another four minutes



Fig. 6. Dry mixing



Fig. 7. Wet mixing

CASTING: Mixed composites are directly poured into a 190 x 90 x 90 mm brick mould by blowing 25 times in three layers. These samples are kept for drying for one day and demoulded after that.



Fig. 8. Casting of Bricks

CURING: The moulded after 24 hours and cured for seven, fourteen, and twenty-eight days. After curing period, samples were kept in water for 24 hours, Water absorption and wet compressive strength were tested on the specimens.



Fig. 9. Produced geopolymer brick specimens



Fig. 10. Produced geopolymer brick specimens kept for drying

V. RESULTS AND DISCUSSION

As per following standard procedure, the tests were conducted:

- Water absorption tested as per IS: 3495 (Part 2)-1992.
- Compressive strength tested as per IS: 3495 (Part 1)-1992.

WATER ABSORPTION:

Bricks were tested for water absorption as per the procedure in IS 3495 (Part 2):1992 by keeping the specimens in water for 24 hours after 7days dry curing in ambient temperature, WA value shall not be more than 20 % by weight. For 24 hours, the test specimens must be totally submerged in water at room temperature.

Water Absorption, (%) = (**Difference in weight** / **Original weight**) x 100

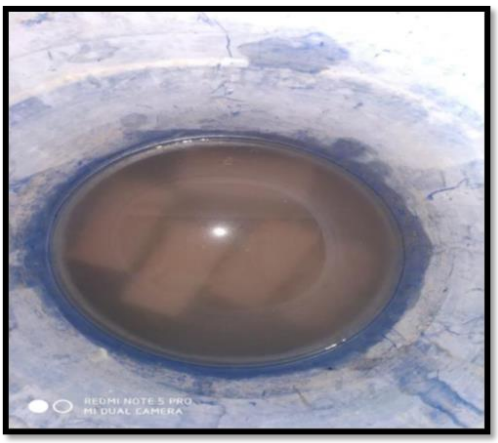


Fig. 11. Geo polymer bricks immersed in water for 24 hours

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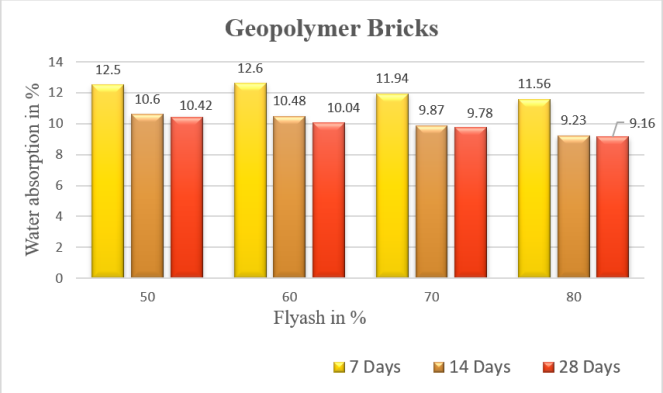
Fig. 12. Geo polymer bricks after 24 hours immersion in water



Fig. 13. Weighing specimens to determine water absorption

Table 3. Water Absorption Test Results for 7, 14 & 28 Days Curing

Sl No	Mix Proportion		Water Absorption in %		
	FLYASH (%)	Red Mud (%)	7 Days	14 Days	28 Days
1	50	50	12.5	10.6	10.42
2	60	40	12.6	10.48	10.04
3	70	30	11.94	9.87	9.78
4	80	20	11.56	9.23	9.16



Graph. 1: Water absorption of GP Bricks

COMPRESSIVE STRENGTH TEST:

According to IS 3495 (Part 1):1992 average Compressive Strength of brick is more than 3.5 Mpa. The CS of the prepared sample was determined according to normal procedure. The results of the tests are listed below.

Compressive strength (Mpa) = $LOAD$ / $AREA$



Fig. 14. Failure crack on specimen when subjected to compression loading



Fig. 15. Compression Strength testing of Geo polymer brick specimen

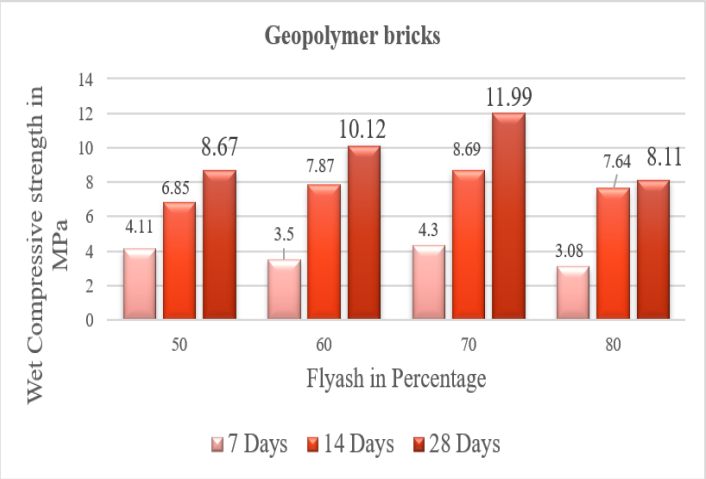
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Table 4. Compression strength test Results for 7, 14 & 28 Days Curing

Sl No	Mix Proportion		Compressive Strength in Mpa		
	Flyash (%)	Red Mud (%)	7 Days	14 Days	28 Days
1	50	50	4.11	6.85	8.67
2	60	40	3.5	7.87	10.12
3	70	30	4.3	8.69	11.99
4	80	20	3.08	7.64	8.11

All results so obtained were greater than 3.5MPa which satisfied code provisions IS 3495:1992 Part 2.



Y-Axis: Compressive Strength in Mpa

Graph. 2: Wet compressive strength of GP Bricks

VI. CONCLUSIONS

From the experimental results, the conclusion reached on the basis of evidence and reasoning is as follows,

• Geo polymerization of red mud and FLYASH can be used as sustainable alternative material for conventional bricks.
• The use of red mud and Flyash based on geo polymer technology to play a major role in the mechanical qualities of brick, with red mud content ranging from 20 to 60% and alkaline activator, compressive strength is achieved in the range of 3.08 to 11.99 N/mm^2, water absorption gets 9.16 to 12.5 %.
• The greatest compressive strength was achieved in this study was at 70% Fly ash and 30% Red mud i.e. 11.99 N/mm^2. Percentage of water absorbed is lower for mix with 70% Fly ash and 30% Red mud i.e. 9.01%`
• Use of Flyash and Red mud in bricks can solve the waste disposal problem.

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